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WORKSHOP TO ASSESS THE EFFECTS OF USING
SEAL-CONTROL DEVICES TO HERD SCHOOLS OF
DOLPHINS IN THE EASTERN TROPICAL PACIFIC

Held at the Southwest Fisheries
Center on 29 November 1989

By

Douglas P. DeMaster

ADMINISTRATIVE REPORT LJ-90-01

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Workshop to Assess the Effects of Using Seal-Control Devices to
Herd Schools of Dolphins in the Eastern Tropical Pacific

Held at Southwest Fisheries Center
on 27-29 November 1989

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Douglas P. DeMaster

January 1990

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Workshop to Assess the Effects of Using Seal-Control Devices to Herd Schools of Dolphins in the Eastern Tropical Pacific

I. Introductory Remarks

On 27-29 November 1989 a workshop was held in La Jolla, CA for the purpose of determining whether the use of seal-control devices (SCD) results in physical impairment or increased mortality to dolphins that are chased and herded in the pursuit of yellowfin tuna by purse-seiners in the eastern tropical Pacific (ETP). Twenty-four people participated in the workshop (Appendix 1). The agenda for the workshop is also given in Appendix 1.

Introductory remarks were given by Douglas DeMaster. Sixteen of the 24 participants were considered voting members of the panel. The rest of the participants were considered observers, who could participate in discussions, but were not asked to vote on any issues. The participants were instructed that they would be asked to review and comment on three manuscripts concerning the possible effects of SCD on dolphins. In addition, the participants were told that they would each receive draft minutes of the meeting by 12 December 1989, a fourth manuscript on audiogenic stress and would be required to comment on these minutes within 10 days. Because it is unlikely that comments from panelists could be incorporated into final versions of the three papers by 1 January 1990, Smith was asked how the decision would be made on the continued use of SCD. He said that a notice of availability and request for comment on the background papers and workshop report would be published in the Federal Register as soon as they became available. Any comments received will be added to the report of the meeting and the background papers to form the administrative record from which the Southwest Regional Director will prepare a decision memorandum and Federal Register notice recommending an agency position on whether to continue the use of the SCD. A final determination must be made by April 1, 1990.

II. Working Paper #1. Identification, chemistry, and behavior of seal-bombs used to control dolphins in the yellowfin tuna purse-seine fishery in the eastern tropical Pacific: Potential hazards by Myrick et al.

ABSTRACT

We examined seven types of seal bombs known to be in use in the fishery. Two US-made, Class-C units contained potassium perchlorate as the oxidizer in a mixture resembling an M-80 pyrotechnic. The others were foreign-made and contained potassium chlorate as the oxidizer which is more reactive and unstable than potassium perchlorate. All seven units probably have a TNT equivalency by weight of 80% or greater and are a danger to dolphins when exploded at close range. Alternative compositions are discussed.

General comments:

Dave Phillips asked if there was any information on any additional effects that may be caused by use of more than one SCD at a time. Myrick commented that in the open water tests (See section on working paper #3) SCD were detonated simultaneously with electronic detonation, but that multiple SCD were not detonated in proximity to one another. Martin Fink commented that due to surface reflection and wave pattern interference, the energy in pressure waves created when multiple SCD were used would not be additive relative to the energy released upon detonating one SCD. Scott Johnson noted that in general the energy of an explosion is doubled when the mass of the explosive is cubed.

Phil Stonebraker made several comments related to the application of explosives in fisheries and wildlife. He noted that 99% of their business involved wildlife applications such as scaring birds away from runways. Between 1968 and 1972 his company was contracted by the military to produce a "standard" M-80 product, which subsequently has been associated with an explosive containing 1.5 gm of photo-flash powder. This product produces a peak sound pressure level of 106 dB relative to 20 micropascal (uPa) at 75 ft. The explosive used in this unit was designed to produce light and noise with relatively little energy being released (i.e., potential for work). Stonebraker noted that based on his experience black-powder (as opposed to photo-flash powder) did not have much potential for use in the application concerning this workshop because it is not a reliable explosive and requires larger quantities to produce an acoustic effect similar to that of photo-flash powder. Finally, Stonebraker commented that if there was concern over the potential damage to dolphins caused by the detonation of SCD, he recommended the panel consider either changing the composition of the SCD to reduce the amount of fuel in these units or reducing the total weight of the powder used in each unit.

August Felando commented that from his experience and based on conversations with numerous skippers, he thought that the basic response of the dolphins to SCD was in response to the sound created by the blast, and not in response to the flash of light associated with the blast. Stonebraker added that black powder would produce less sound per weight of explosive used than would flash powder.

Darlene Ketten noted that a loss of hearing in humans in the high frequency range was generally associated with exposure (in air) to high-velocity explosives or cranial injuries; loss of hearing in the low frequency range is generally associated with circulatory or genetic problems.

Bill Perrin asked Stonebraker what weight of powder in a SCD would be associated with an impulse pressure wave that was not likely to cause physical injury to a dolphin at close range. Stonebraker

responded that the measurements referred to in Myrick et al. should be considered only as first-order approximations, as they were only rough, empirical measurements. He noted that the Department of Transportation (DOT) picked 2.56 gm (40 grains) of explosive in an arbitrary fashion that was not related to the energy released by Class-C explosives (SCD are classified as a Class C explosive by DOT). Furthermore, it would be very difficult to give a precise answer because of problems such as non-uniform wave propagation and variability in the depth at which units explode.

Johnson commented that it should be kept in mind that dolphins do not hear like humans do (e.g., dolphins do not have an eardrum), do not seem to experience pain when presented with a loud noise, and are likely to have a middle ear reflex that would protect the hearing apparatus from potentially harmful pressure waves. He added that there was some evidence for beluga that these animals do not lose their high frequency range hearing with age as humans do and that dolphins in general have hearing that is relatively insensitive to sounds below 40 Hz. Ketten responded that dolphin hearing could still be damaged in frequency ranges that were quite different from the peak frequency of a SCD. She added that damage to the hearing apparatus of dolphins caused by high-velocity explosives would generally occur in the interior third of the basal membrane. She noted that the basal membrane is not uniformly damaged by pure tones.

Martin Hall asked if there was data on the propagation pattern of the pressure wave created by the explosion of a SCD. Myrick noted that because most of these units are bottom weighted they would tend to sink in a uniform attitude, and, therefore, the propagation pattern might be relatively constant. Stonebraker corrected that statement noting that while laboratory studies had not been done to address this question, there were studies that suggested that the pressure wave will be propagated in a pattern that is related to where the container of the SCD first breaks open during the explosion and that this was highly variable. Randy Robinson commented that the depth of detonation would be a function of how long the units were held after being lit and before being thrown, how long the fuse was, and how deep the fuse was embedded into the powder. He thought that in general the units produced by his company would detonate between 2-3 meters. Concerning the possible adverse affects to dolphins, it was noted by some that one possible mitigation measure would be to weight and construct the units so that the pressure wave would propagate in a vertical direction in general. Others were not convinced this would reduce the potential effects of SCD on dolphins because it was necessary to assume that animals in general were neither above nor below SCD as they explode. The panel agreed that data needed to resolve this question were not available. Stonebraker added that it would be relatively easy to develop a SCD that would "break" consistently in the same place. He further noted that the propagation pattern

could be focused either up or down, as opposed to radiating equally in the vertical axis. Frank Awbrey noted that in terms of minimizing injury to dolphins it would be best if the pressure wave propagated in a spherical pattern.

Hall recommended that some type of dye be incorporated into the US made SCD. This would facilitate the recognition of where and how many SCD were used by the observer. Stonebraker noted that this modification would be relatively easy to accommodate.

Specific comments (non-editorial):

P. 1: Add reference to addresses of non-U.S. SCD manufactures or add as an appendix.

P. 3, par. 1: Don't need type-3.

P. 5, par. 1: Stonebraker noted that the validity of the military report on TNT equivalency was of questionable value and was generally not well accepted in the pyrotechnical community. Generally, the energy level of an explosive is not well correlated with its TNT equivalency. Also, "1" in perchlorate formula should be lower case.

P. 10, par. 1: Close range should be changed to 0.5 m.

P. 11, par. 1: It was agreed that this section would be rewritten to incorporate consideration of changing composition and weight of powder currently used in U.S. made SCD, as well as investigating the potential for other explosives. Stonebraker recommended the use of 1.5 gm, but noted that if the foreign made units were going to be used by the fleet and would continue being manufactured with more than 2.5 gm of powder, they would be used preferentially by the U.S. purse seine fleet.

III. Working paper #2. The use of seal bombs on dolphins in the eastern tropical Pacific yellowfin tuna purse-seine fishery. Cassano et al.

ABSTRACT

Marine Mammal Set Log forms completed by Service tuna-porpoise observers were examined to determine whether seal-bomb use increases dolphin mortality within a set and to detect when, during a set, seal bombs were used. Seal bombs were used in approximately 38% of dolphin sets in 1989. Dolphin mortality, as measured by dolphins killed per set, was not significantly correlated with seal bomb use, but was significantly correlated with species composition of the school (common dolphins versus non-common dolphins). Most seal bomb use occurs within a dolphin set during the chase and encirclement stage.

General Comments.

Felando questioned the use of the term, "exposure", in the report. Cassano explained that he defined dolphin-exposure as the number of dolphins in a school, where at least one SCD was used within 100 yd of the school. Hall noted that because the number of SCD used during a set was not monitored and that this number is highly variable (i.e., between 1 and 600 SCD used per set), the value of calculating dolphin-exposures was obscure. Gary Smith questioned the value of using 100 yd in evaluating the effects of SCD use on dolphins. He suggested a more reasonable distance to use would be 10 ft. Cassano noted that 100 yd was used initially because of a report by Awbrey and Thomas that damage to hearing could result from the pressure wave created by a SCD at 100 m (See discussion of working paper #3). Perrin and others noted that it was very difficult for observers to estimate 100 yd at sea and that many of the SCD were tossed from either the speed boats or the helicopter. This latter fact would cause observers to underestimate the use of SCD in a set. Hall noted that difficulties in estimating the 100 yd distance would not necessarily cause a negative bias. Robinson noted that some unknown fraction of SCD explosions should be associated with a plume of water that may be visible to the observer on the seiner. Ken Martin commented that there was no way for the observer to know the distribution of dolphins under the water during the chase. There was general agreement that estimating dolphin-exposures would not contribute to the analysis and that this aspect of the report should be deleted. Phillips stated that in view of the fact that SCD are used from helicopters and speedboats at considerable distance from the observer on the purse seiner, that the levels of SCD use found in the study must be considered minimum estimates.

Hall noted that SCD were used in purse-seining operations in three very different ways: 1) during the chase to control the movement of the dolphins, 2) during the chase to cut out part of the dolphin group that had no tuna associated with it, and 3) during and after backdown to drive dolphins out of the net. Mortalities or physical injuries associated with the use of SCD during the chase stage of the set were difficult to quantify. In the latter two cases, SCD may actually contribute to reducing the number of dolphins that would have been killed or injured during backdown, which to some unknown degree may offset the number of injuries or deaths related to the physical trauma caused by the detonation of a SCD in close proximity to a dolphin. Phillips commented that there were no data to support this hypothesis. Phillips indicated that several observers have provided information suggesting that use of SCD in the backdown channel exacerbated dolphin entanglement by scaring animals into net canopies. Ketten commented that the "intent" to release animals by using SCD in combination with backdown procedures was not the same as actually causing a reduction in dolphin mortality and relating the reduction to the use of SCD.

Cassano reported that seven of the 19 skippers in the data base did not use SCD at all and that 45% of the skippers accounted for over 50% of SCD use. He added that most of the SCD use occurred during encirclement; the next most common usage occurred during backdown. He suggested that it might be possible to tease out the effects of SCD use on dolphin mortality by comparing kill rates of skippers who do not use SCD with those that do. There was general agreement that this analysis should be performed and added to the report. Felando noted that the skipper who has had the lowest rate of dolphin mortality over the last three years (as measured by dolphins killed per ton of tuna landed) regularly uses SCD. Solomons reported that in his analysis of the US fleet's use of SCD in 1989 he found that the usage rate during backdown was less than during chase (based on 2600 trips in NMFS and IATTC database). Cassano noted that the database he used for his analysis was based on trips with NMFS observers only and was through August. He expected to add another 20 trips or 600 dolphin sets to the database prior to finalizing this report.

Phillips noted that based on interviews with 11 observers in 1989, over 50% of the trips had use of illegal (i.e., units that would not qualify as Class-C explosives by DOT) SCD and that 9% of the trips had SCD used in an illegal manner (i.e., SCD were clustered prior to use). Robert Solomons responded that there would be over 100 US trips this year and over 3000 dolphin sets and that a sample of 11 interviews was not adequate to represent fleet-wide usage rates. Cassano added that some of the observers that he interviewed and a number of previous observers, who currently work at the Center, reported that SCD were used from helicopters to get the dolphin schools to run. This was done because it is easier in some instances to make a determination as to whether tuna are associated with dolphins, when the dolphins are running.

Phillips questioned the value of database I (prior to coding SCD use on the Set Log forms). He suggested that most of the inferences about SCD use should be based on database II. There was unanimous agreement concerning this suggestion. Ketten suggested the possibility of having the skippers fill out SCD use forms at sea. There was general agreement that this suggestion would be difficult to implement and would still result in data of questionable value. Johnson suggested that skippers as well as observers be interviewed when a trip returns concerning the use of SCD. The panel unanimously agreed with this recommendation. Smith noted that very little information is available to identify the use and benefits of SCD. This information is important for understanding the present need for SCD and will become even more important in any consideration to justify their continued use in the future. He urged that an effort be made to add any available information that may be obtained from veteran observers and captains to the report, even if it is qualitative in nature. Felando suggested that an analysis of SCD use in log-and school-

fishing be performed. There was general agreement that this should be done.

Based on the previous discussion the panel unanimously agreed that the existing data elements considering the use of SCD were inadequate. Specifically, a new form should be developed that incorporated data on the number and types of units used, whether units were used in clusters, and where in the set SCD were used. Without these data, it would not be possible to determine the effectiveness of using SCD to increase tuna landings and the extent to which SCD use is associated with dolphin mortality and injury. Hall added that the life history forms should be modified to cue the observer to record unusual "scars" on the animals that might be associated with the use of SCD within 0.5 m.

Hall recommended that longitudinal studies on marked or tagged animals was needed to determine the cumulative effects of SCD on dolphins. In particular, with tagged animals it would be possible to estimate the number of times individual animals are chased and set upon over a specified time period. There was general agreement that this idea was worth pursuing, but it was recognized that such a study was a major undertaking in terms of funding and participation by the tuna fleet.

Specific comments:

P. 3, par. 1: Add the phrase, "physical impairment", to the sentence.

P. 5, par. 2: Move most of the text, tables and figures related to database I to an appendix.

P. 10, Table 3: Delete text and tables related to estimates of dolphin-exposures.

P. 15, Table 7: Delete use of sets where use of SCD was undetermined.

P. 17, par. 1: Add description of methods and results of multiple regression analysis on database II. Where possible report whether differences in mortality rates and injury rates between sets with and without SCD use are statistically significant.

P. 24: First sentence should read, "Six observers interviewed ...". Refer to Class C explosives, not Class III.

IV. Working paper #3. Potential for physical injury, other than hearing damage, to dolphins from seal bombs in the yellowfin tuna purse-seine fishery: Implications from open water tests. Myrick et al.

ABSTRACT

We exploded pre-positioned seal bombs on stationary underwater targets including air-filled cans, water-filled cans, dolphin carcasses and cages of live fish to consider 1) whether the explosives were strong enough to cause direct physical injury to dolphins, and 2) if so, what were safe standoff ranges. Based on our results we expect that a Class-C seal bomb will cause injury when detonated within 0.5 to 0.6 m of a dolphin. We estimated a safe standoff distance to be 4 m. Throughout this study, we have struggled with the difficulty of using studies of terrestrial mammals in predicting the effects of seal bombs on free-ranging dolphins.

General Comments:

Hall noted that three of 24 SCD failed to detonate and questioned whether this was expected. Robinson commented that this was a much higher failure rate than they found in their product, which has failure rates of 6% or less. Myrick added that all of the failures were likely due to modifications related to the electronic detonation.

Smith asked at what point does physical injury start to compromise the animal's survivability. There was general agreement that the data to answer this question do not exist.

Phillips commented that estimates of safe stand-off distances in this paper only refer to physical injuries, and not hearing damage. Perrin noted that the cumulative effects of SCD use could not be inferred from the tests described in working paper #3.

Wiley recommended that actual measurements of the explosion pressure wave be made in the future and noted that inferential data, while useful, was difficult to interpret. Most of the panel members felt the at-sea studies provided valuable results concerning the approximate energy level of the pressure wave created by a SCD. In general, it was agreed that physical injury to dolphins would be caused when legal SCD exploded within 0.5m of an animal. Several of the foreign made units were thought to be more damaging to dolphins than U.S. made SCD.

Specific comments:

P. 5, last paragraph: A number of panel members thought that this paragraph was worded poorly and should be rewritten. In particular, the word, "estimated", should be replaced with "extrapolated" and the last phrase should be deleted.

P. 4: "1" in perchlorate and chlorate should be lower case.

P. 6, par. 3: Martin Wiley noted that in some species of fish with swimbladders, it was very difficult to tell whether they had been "damaged" by an explosion. Ketten added that she wondered about problems in determining damage to the soft tissues in the fish or dolphin carcasses used in the open ocean tests (i.e., brain tissue). Myrick noted no histology was done on any of the frozen carcasses nor were any x-rays taken prior to or after the tests. Kerry Mahoney noted that it would be very difficult to discriminate damage from freezing and handling from damage due to the SCD in the tests described in working paper #3. The question was raised as to the possibility of shark damage to any of the carcasses used in the field trials. Myrick and others considered this unlikely. There was general agreement that the macroscopic analysis of tissues following the at-sea trials were relatively insensitive.

P. 7, par. 3: Hall and others disagreed that there was strong uniformity in the directionality of the explosive force. It was agreed that the direction of the propagating wave was highly variable relative to the orientation of the unit.

P. 10: Describe how Yelverton defined "injury". There was a discussion as to whether Myrick's use of injury was the same as Yelverton. Smith asked if impairment and injury were synonymous. Ketten noted that in workplace related injuries to humans, impairment is generally associated with a permanent reduction in function, whereas the term injury generally refers to temporary change in function.

P. 12, par. 1: Expand on differences between pressure wave caused by floating M-80 and a SCD.

P. 14, par. 1: Clarify what is meant by "brain rupture" (i.e., was CSF fluid draining out of ears?). Ketten noted that tears in the eardrum of humans of less than 25% will generally heal on their own; tears of greater than 25% need to be surgically repaired.

P. 14, par. 4: Perrin noted many dolphin calves weigh on the order of 40 kgs and this paragraph should be rewritten to reflect that.

P. 15, par. 1: There was general agreement that injuries caused by underwater explosives to submerged terrestrial animals would be different from injury to dolphins. There was not agreement that dolphins would be necessarily better protected in terms of physical (i.e., non-hearing related) injury.

P. 14, par. 2: There was general agreement that at close range, U.S. made SCD will cause injury to dolphins. Close range was understood to mean approximately 0.5 m.

V. Summary of studies and findings concerning the effects of SCD use on dolphin hearing.

Phillips commented that the Federal Register Notice concerning the proposed ruling on the use of SCD states that the energy levels produced by these units were below the threshold that would cause hearing damage to dolphins. A reference to Awbrey and Thomas (1984) is given. Awbrey noted that the above mentioned reference was from an earlier draft of a contract report to NOAA and that a better reference was a paper of his published in 1987 (Awbrey and Thomas). He stated that it was not possible to estimate the sound level that would cause damage to dolphin hearing. Furthermore, it is quite possible that certain frequencies of sound produced by a SCD would cause damage to dolphin hearing at other frequencies. Awbrey noted that the mean sound exposure level (energy integrated over time) of a SCD was 197 dB re 1 micropascal at 1 m in shallow water (i.e., 25m) and 169 dB at 1 m in deep water (i.e., 300m).

Ketten noted that in humans 85 dB (re 20 micropascals) noises would cause damage in 80% of the exposures. Gun shots were roughly equal to 120 dB re 20 micropascals at 5 ft and this will cause loss of hearing at 5 kHz and above. Ketten noted that 120 dB re 20 micropascals was 140 dB above the threshold of hearing at frequencies for which humans are most sensitive. Awbrey and others noted that hearing in humans was much more easily damaged by in-air blasts relative to in-water blasts. There was unanimous agreement that this should also be true for dolphins. Awbrey commented that he has observed beluga whales approaching underwater sound generators that were putting out 150 dB (re 1 micropascal) at 1m. In fact, these animals were observed actually resting their heads against the projection screen.

Ketten suggested the possibility of measuring temporary threshold shifts (TTS) in dolphins as an approximation to when permanent hearing loss would be caused. She added that it might be useful to start testing with 4 kHz pure tones. There was general agreement that this approach should be pursued. Ketten further recommended that fresh material (i.e., heads) be collected at sea and exposed to 4 kHz tones. A microscopic analysis of the hearing apparatus might reveal damage.

Myrick reported on the results to date of collecting cochlea opportunistically on tuna vessels. The Service has a contract with a Dr. B. Bohne, an otologist, to look at preserved cochlea. To date, incomplete preservation of the tissues have prevented any meaningful analyses from being performed. This work will continue over the next few months. Ketten noted that some of the techniques used by the observers at sea were different from the ones she would use. Myrick said he would discuss this with her at a later date.

Perrin, Phillips and Christina Lockyer noted that hearing in ETP dolphins that were set on by the tuna fleet was likely to be critical to the survivability of these animals because of their need to use acoustic signals to locate and return to their school following the chase and backdown. This factor may be more

important than the possible loss of foraging ability due to hearing impairments. Johnson asked if there were any reports of healthy deaf dolphins in the wild. None of the panel members could think of any references other than Johnson, who thought there might be data on a deaf Grampus in captivity at the Naval Oceans Systems Center in San Diego.

Hall suggested that the Service should make greater use of carcasses that are used in the training of observers. Material from these animals could relate to many of the issues raised during this workshop. In particular careful necropsies of animals following the dissection training should be initiated.

VI. Working paper #4. Effects of noise on animals: Implications for dolphins exposed to seal bombs in the eastern tropical Pacific purse-seine fishery by Majors and Myrick.

ABSTRACT

This literature review was conducted on studies dealing with audiogenic stress on laboratory, domestic, and wild animals. Noise stress is known to produce disturbances in various biochemical and physiological activities in animals and humans. Lethality usually depends on the intensity of the noise. The use of seal bombs to control dolphins in a chase, prevent dolphins from escaping open parts of the net during encirclement, and to facilitate dolphins' release during backdown is hypothesized as potentially stressful to these animals. Stressful effects of noise on auditory and non-auditory functions have been found in dogs, cats, chickens, guinea pigs, mice, rats, and rabbits tested in the laboratory. Noise stress can adversely affect the quantity and quality of various functions (e.g., milk or egg production). Animals in the wild have been observed to respond to audiogenic stressors by altering their migration patterns, habitat use, and home range. Studies have also shown that, when animals are unable to escape noxious noises, injury to the inner ear, disorientation, convulsions and death may result.

This paper was distributed at the end of the workshop with a request that comments on this paper be included with the comments on the draft minutes.

VII. General Recommendations

There was general agreement that legal SCD when exploded more than 4m from a dolphin would probably not result in physical injury, while use of SCD within 0.5m will cause physical injury. Also, the closer the explosion is to an animal the more likely the severity of the injury would be such that it would compromise the animal's future survivability, but that at present there are no data to quantify the relationship between distance and the proportion of injuries that would ultimately lead to increased mortality.

It was agreed that data do not exist to determine if the use of legal SCD will cause permanent hearing damage in dolphins, but the panel was concerned with the potential for permanent hearing loss caused by the use of SCD. In particular, the panel was concerned about the long-term or chronic effects of SCD on dolphin hearing.

Panel members agreed that the data do not exist to determine whether the use of SCD could or does contribute to a reduction or increase in total dolphin mortality. To address this problem, the panel recommends that a more detailed form concerning the use of SCD on the US fleet be developed and implemented as soon as possible.

Concerning research needs that were identified during the workshop, the following were unanimously agreed upon:

A. Determine the effectiveness of SCD in purse seine fishing for tuna.

1. Determine the effectiveness of SCD in "porpoise fishing", log fishing, and school fishing.

2. Compare dolphin mortality patterns of skippers who use SCD with mortality patterns of skippers who do not use SCD.

3. Determine how, when, and why SCD are used by those skippers who have lower than average dolphin mortality rates.

4. Determine if SCD contribute to the release of dolphins during backdown or to the capture of fewer dolphins.

5. Design and implement a new data form for determining the use patterns of SCD (i.e., number and types of units used, how used, when used, etc.).

B. Develop and test other mixtures and fuels for SCD that would either reduce peak pressures or total energy. In addition, develop a unit that incorporates some type of dye that would be visible in the water upon detonation.

C. Investigate the types of damage caused by the use of SCD.

1. Necropsy sample of animals at sea (fresh) or at a later date (frozen) to determine cause of death.

2. Determine mechanical damage to ear by exposing fresh post-mortem material to experimentation.

3. Conduct temporary-threshold shift studies on captive dolphins.

D. Determine feasibility of estimating the number of repeated exposures to individual animals by marking/tagging studies.

E. Repeat the at-sea experiment with equipment capable of directly measuring pressure wave levels.

Appendix 1

List of Workshop Participants and Agenda for Workshop on Seal-bomb 27 - 29 Nov 1989, Southwest Fisheries Center, La Jolla Ca.

Participants

1. Dr. Frank Awbrey	SDSU/Hubbs' Marine Res Inst.	Bioacoustics & seal-bomb sound
2. Dr. Raymond Tarpley	TX A&M Univ.	Dolphin vet med functional anat.
3. Dr. William Perrin	SWFC NMFS	Dolphin morphol Tuna-dolphin bio.
4. Dr. Christina Lockyer	SWFC/NMFS (Visiting Scientist)	Dolphin bio/anat.
5. Mr. Dave Phillips	Spokesperson for Enviromental Commun.	Earth Island Inst.
6. Mr. August Felando	Spokesperson U.S. Tuna Indust.	Gen. Manag. Amer. Tunaboat Assn.
7. Mr. Gary Smith	NMFS/SWR	MMPA management
8. Dr. C. Scott Johnson	NOSC San Diego	Dolphin bio. vet. med. acoustics
9. Mr. Phil Stonebraker	StoneCo Inc.	U.S. seal bomb mfg.
10. Dr. Martin Hall	IATTC	ETP Dolphin-tuna fishery res.
11. Mr. Martin Fink	SD Co. Sheriff's Dept.	Forensic sientist explosives anal.
12. Dr. Martin Wiley	US Nav Surf Weap Cent.	Underwater explosion injury marine verts
13. Dr. Kerry Mahoney	SD Co. Vet Path.	Pathology/injury to vertebrate animal.
14. Mr. Randy Robinson	California Seal Bomb Corporation (Aternate for 9)	Seal-bomb Distributor
15. Dr. Doug DeMaster	SWFC NMFS	Workshop facilitator
16. Dr. Al Myrick	SWFC NMFS	Workshop convenor/ presenter
17. Lt (jg) Ed Cassano	SWFC NOAA Corp	Presenter

OBSERVERS

1. Earth Island Inst.	Ms. Karen Glass	Conservat.
2. Calif. Seal Control Corp. San Pedro, CA	Mr. Randy Robinson	Seal bombs Distributor
3. Greenpeace		Conservat.
4. Center Marine Mar. Conserv.	Dr. Karlene Ketten	Dolphin hearing damage
5. Friends of Animals	Mr. Zephyr Carlyle	Attorney (FofA)
6. NMFS SWR	Mr. Norman Mendes Program Coordinat.	Tune/dolphin data collect.
7. NMFS SWR	Mr. Dick Butler	Tuna/dolphin data collect.
8. Porpoise Rescue Foundation	Mr. Robert Solomons	Tuna/dolphin res.
9. Earth Island Inst.	Dr. Ken Martin Long Marine Lab UCSC	Dolphin acoust.
10. NMFS	Mr. Charles Oliver	SWFC co-author dolp phys inj
11. NMFS	Mr. Anthony Majors	SWFC author dolp stress
12. NMFS	Ms. Cheryl Glick	SWFC co-author SB chem analysis

AGENDA

27 Nov.

1:00 PM	Welcome and approve agenda
2:00	Seal Bomb chemistry paper presentation
2:30	Discussion/questions
3:00	Recommendations
3:15	break
3:30	Seal Bomb Use paper presentation
4:00	Discussion/questions
6:00	Adjourn

28 Nov.

9:00 AM	S.B. Use Discussion/questions continued
11:00	Recommendations
11:30	break
11:45	(more)
12:30 PM	break for lunch
1:45	Seal Bomb Phys Injury paper presentation
2:15	Discussion/questions
3:45	break
4:00	Discussion/questions continued
6:00	Adjourn

29 Nov.

9:00 AM	Recommendations
10:30	Brief status report on ear bone analyses
11:00	Discussion/questions
11:30	break
11:45	Dolphin stress response paper presentation
12:15 PM	Discussion/questions
12:45	Recommendations concerning use of sealbombs
2:00	Adjourn.

